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Rice and red rice interference. II. Rice response to population densities of three red rice (*Oryza sativa*) ecotypes

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Red rice, which grows taller and produces more tillers than domestic rice and shatters most of its seeds early, is a major weed in many rice-growing areas of the world. Field experiments were conducted at Stuttgart, AR in 1997 and 1998 to evaluate the growth response of the Kaybonnet (KBNT) rice cultivar to various population densities of three red rice ecotypes. The ecotypes tested were Louisiana3 (LA3), Stuttgart strawhull (Stgstraw), and Katy red rice (KatyRR). Compared with KBNT alone, LA3, the tallest of the three red rice ecotypes, reduced tiller density of KBNT 51%, aboveground biomass at 91 d after emergence (DAE) 35%, and yield 80%. Stgstraw, a medium-height red rice, reduced KBNT tiller density 49%, aboveground biomass 26%, and yield 61%. KatyRR, the shortest red rice, reduced KBNT tiller density 30%, aboveground biomass 16%, and yield 21%. Tiller density of rice was reduced by 20 to 48% when red rice density increased from 25 to 51 plants m^{-2}. Rice biomass at 91 DAE was reduced by 9 and 44% when red rice densities were 16 and 51 plants m^{-2}. Rice yield was reduced by 60 and 70% at red rice densities of 25 and 51 plants m^{-2}, respectively. These results demonstrate that low populations of red rice can greatly reduce rice growth and yield and that short-statured red rice types may affect rice growth less than taller ecotypes.

Nomenclature: Red rice, *Oryza sativa* L. ORYSA, 'KatyRR', 'LA3', 'Stgstraw'; rice, *Oryza sativa* L., 'Kaybonnet'.

Key words: Competition, leaf area index, population density, rice growth, tiller density.

Red rice is a major agricultural weed in most areas where rice is grown and is the most troublesome weed in the Southern Rice Belt (Webster 2000). Severe economic infestations of red rice in the Southern Rice Belt were estimated at 65% of rice area in Louisiana, 25% in Arkansas, Texas, and Missouri, and 15% in Mississippi (Gealy et al. 2000). Red rice generally grows taller and produces more tillers than domestic rice and shatters most of its seeds early (Diarra et al. 1985) and effectively reduces rice yield and marketability (Saldain 1997; Smith 1981). In a 4-yr period in the late 1980s, red rice cost Arkansas rice producers \$3.24 million for grade discounts alone. Additional losses accrued from competition, harvest complications, milling quality reductions, and increased chemical application costs (Guy et al. 1992). Smith (1979) reported that an estimated \$50 million annual loss in yield and quality of commercial rice in the Southern Rice Belt was attributed to red rice.

Differences in time of emergence, plant height, tillering capacity, leaf area index (LAI), and growing periods affect the growth, development, and competitveness of weeds (Jennings and De Jesus 1968; Smith 1988). In rice, yield loss is dependent on the cultivar of domestic rice and the density and ecotype of red rice. Diarra et al. (1985) reported that the number of grains per panicle of cultivated rice was reduced 18% by five red rice plants m^{-2} and 70% by 215 red rice plants m^{-2}. Kwon et al. (1992) found that the yield of 'Lemont', a short-statured rice cultivar, was reduced by 90% with 35 red rice plants m^{-2}, whereas the yield of 'Newbonnet', a taller rice cultivar, was reduced by 67% with 40 red rice plants m^{-2}. Do Lago (1982) reported that red rice phenotypes were at least 40 cm taller than 'Lebonnet' (95 cm), the shortest rice cultivar, and about 22 cm taller than Starbonnet (113 cm), the tallest cultivar. The semidwarf *indica* rice PI 312777 reduced growth of the taller Stuttgart strawhull red rice (Estorninos et al. 2005) and barnyard grass (*Echinochloa crus-galli*) (Gealy et al. 2003) by producing more and early tillers. Recent reports have documented significant genetic differences among red rice phenotypes found in U.S. rice fields (Gealy et al. 2002; Vaughan et al. 2001). However, reports on the competitiveness of rice against the various red rice phenotypes have been limited. The objective of the study was to determine the growth and yield response of Kaybonnet (KBNT) rice when grown with three distinctive red rice ecotypes at three population densities.

Materials and Methods

The experiment was conducted at the Rice Research and Extension Center, Stuttgart, AR, from May to October of 1997 and 1998 on a Crowley silt loam (fine, montmorillonitic, thermic Typic Albaqualf) soil. The design of the experiment was split plot. The main plots were the following red rice ecotypes: (1) Stuttgart strawhull (Stgstraw), a prominent, awnless, early-maturity, 122-cm-tall medium-grain red rice ecotype from Arkansas (Gealy et al. 1999); (2) Katy red rice (KatyRR), a suspected hybrid derivative (from a long-grain commercial rice and red rice), awnless, intermediate-maturity, 114-cm-tall long-grain red rice ecotype from Arkansas (Estorninos et al. 2002; Gealy et al. 2002), and (3) Louisiana3 (LA3), an awned, late-maturity, 152-cm-tall medium-grain red rice ecotype from Louisiana (Estorninos et al. 2002; Gealy et al. 1999). The red rice ecotypes in this study have been characterized previously using 'simple sequence repeats' molecular marker analysis (Gealy et al. 2002). The red rice main plots were arranged as a randomized complete block design with four replications. KBNT, the cultivar grown in competition with the three red rice ecotypes, is a 102-cm-tall long-grain tropical *japonica* cultivar from Arkansas (Gravois et al. 1995; Slaton et al. 2001). In 1997, the subplots were four densities of red rice established by sowing red rice at 0 (rice alone), 7, 13, and 20 kg ha^{-1}. Because the population densities of red rice in 1997 were lower than expected, sowing rates were doubled to 0, 14, 26, and 40 kg ha^{-1} in 1998.

The field was prepared using the standard practices for drill-seeded rice recommended in Arkansas (Slaton and Cartwright 2001). After red rice was broadcast, KBNT rice was drill-seeded at 100 kg ha^{-1} 2 to 3 cm deep, into plots with nine 0.18-m-wide by 6.25-m-long rows. A heavy roller was pulled across plots parallel to drill rows immediately after drill sowing to bury the red rice seeds shallowly and to firm the soil. At 5–7 d after emergence (DAE), plots with low red rice emergence were transplanted with seedlings to maintain appropriate densities among replications.

Propanil at 4.0 kg ai ha^{-1} and bentazon at 0.6 kg ai ha^{-1} were tank-mixed and applied 25 DAE using a CO_2-pressurized backpack sprayer at 190 L ha^{-1} for general weed control. Nitrogen in the form of urea was broadcast at 135 kg ha^{-1} in three equal portions at 28, 49, and 70 DAE. The permanent flood was established 28 DAE, immediately after the first urea application, and was maintained at a depth of 5 to 10 cm until approximately 2 wk before the expected harvest date.

The initial densities of red rice ecotypes and rice were recorded at 21 DAE. Growth and development of red rice and cultivated rice were determined by destructive sampling in 25-cm by 25-cm quadrats near both ends of each plot at 49, 70, and 91 DAE. Sampling dates were treated as a sub–subplot factor. Tiller number at 49 (maximum production) and 70 DAE and leaf area and plant height at 49, 70, and 91 DAE were recorded for both red rice and rice. At each sampling, red rice and rice were separated and the leaf area of 10 subsampled plants was measured using a portable leaf area meter[1]. LAI was calculated from the equation:

$$\mathrm{LAI} = \frac{\text{total photosynthetic leaf area}}{\text{total ground area of the two quadrats}} \quad [1]$$

Total leaf area in the two quadrats was estimated by multiplying the total number of tillers in both quadrats by the measured leaf area of the 10 subsampled tillers. The total area for the two quadrats for broadcast-seeded red rice was 0.125 m^{-2}. Since two rows of rice were included in each quadrat, the effective total area of rice in the two quadrats was 0.18 m^{-2} (i.e., 36 cm $\times$ 25 cm $\times$ 2). Plants were then dried at 50 C for at least 3 d, and the aboveground biomass was determined and expressed as gram per meter square.

Fifteen red rice panicles in each plot were bagged with perforated, opaque plastic bags[2] at the dough stage to assure capture of all seeds. At maturity, the bagged red rice panicles were harvested and threshed by hand. Cultivated rice grain yield was determined by hand-harvesting the four middle rows (0.71 m wide) and middle 2-m length in each plot (1.42 m^2). Grains from red rice panicles were weighed and the yield per panicle determined. Red rice yield per panicle was multiplied by the total number of red rice panicles present in the 1.42-m^2 cultivated rice sampling area. All grain yields were adjusted to 12% moisture[3] and expressed as kilogram per hectare.

Data were subjected to analysis of variance using SAS Software[4], and means of significant main effects or interactions were separated using Fisher's protected least significant difference (LSD) test at the 5% level of probability. Data in 1997 and 1998 were analyzed separately because of the differences in red rice populations. Within each year data are presented for significant interactions, if present, and for main factors if interactions were not significant.

Results and Discussion

General

The initial red rice populations at 21 DAE resulting from the sowing rates 7, 13, and 20 kg ha^{-1} in 1997 were 16, 24, and 31 plants m^{-2}, respectively. When each of the sowing rates was doubled in 1998, the resulting red rice populations were 25, 32, and 51 plants m^{-2}. Rice density was 291 plants m^{-2} in 1997 and 363 plants m^{-2} in 1998.

Red Rice and Rice Plant Height

Stgstraw and LA3 were consistently taller than KatyRR in each year. The 2-yr average heights were 119 cm, 132 cm, and 100 cm for Stgstraw, LA3, and KatyRR, respectively. Height of rice was reduced by red rice interference both years, but was differentially affected by red rice ecotype only in 1998. In 1998, height of rice from 91 DAE to harvest was reduced 9% by LA3, 7% by Stgstraw, and 6% by KatyRR. Red rice population densities did not affect rice height. In 1997, reduction on KBNT rice height was detected only at harvest (145 DAE) when red rice population density increased from 24 to 31 plants m^{-2} [99 cm vs. 95 cm; LSD (0.05) = 3.0]. These results differ from earlier findings in which a tall red rice biotype reduced rice height as early as 60 DAE (Kwon et al. 1992).

Red Rice and Rice LAI

The LAI values of the three red rice ecotypes were similar across red rice densities and time of sampling in 1997 (data not shown). In 1998, the LAIs of Stgstraw were 7.8 and 6.0 and for LA3 were 9.4 and 8.3 at 70 and 91 DAE. These were higher [LSD (0.05) = 2.0] than KatyRR, which were 3.7 and 3.3, respectively. The taller LA3 had about 31% greater LAI than Stgstraw at 91 DAE. These distinct differences among red rice ecotypes (Noldin et al. 1999) could potentially affect their interference intensity because LAI is generally associated with biomass production and competitiveness (Ni et al. 2000). Averaged over all ecotypes, LAI of red rice generally increased with planting density. The differences in leaf expansion among the three red rice ecotypes as well as the increased densities did not measurably affect the LAI of rice at the generally low red rice populations in

1998

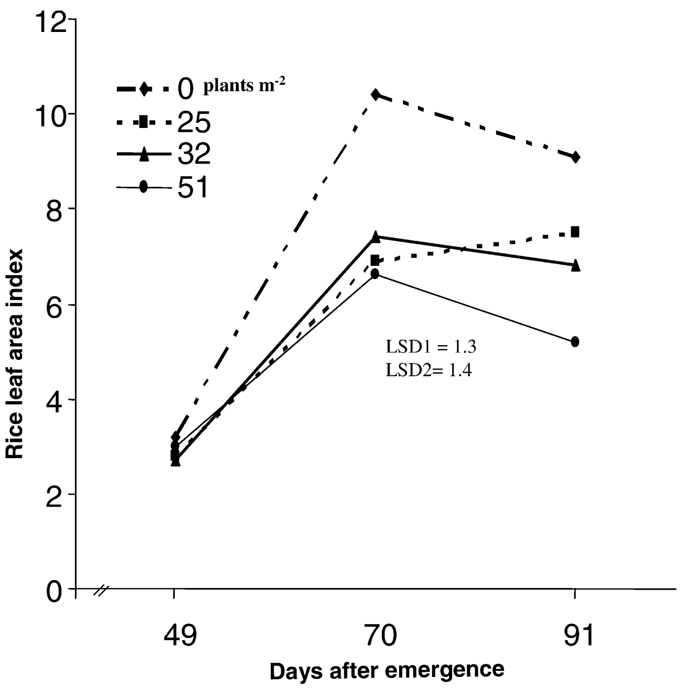

FIGURE 1. Rice leaf area index in 1998 as influenced by red rice population densities at three stages of growth. Data were averaged over three red rice ecotypes. Least significant difference (LSD)1 (0.05) compares times of sampling means at the same population density; LSD2 (0.05) compares population density means for the same or different time of sampling.

1997. In 1998, the LAI of rice grown with red rice was lower than without red rice at 70 and 91 DAE, but was similar at 49 DAE (Figure 1), probably because less competition occurs during the first 49 DAE (Fischer and Ramirez 1993). This also demonstrates that rice had maximized tillering at about 49 DAE, whereas red rice continued until 70 DAE (Table 1). Diarra et al. (1985) reported that red rice can produce tillers season long. In other research, red rice reached maximum LAI at 60 DAE and could have affected rice leaf expansion before rice reached maximum LAI at 80 DAE (Kwon et al. 1992). At 70 DAE in 1998, the LAI of rice grown with red rice was 29 to 36% lower than without red rice competition, but was comparable when red rice density increased from 25 to 51 plants m^{-2}. However, at 91 DAE, the red rice density of 51 plants m^{-2} reduced rice LAI by 31% compared with the lowest density and by 24% when rice was grown with 32 red rice m^{-2}. In greenhouse studies, Estorninos et al. (2002) found that LA3 and KatyRR ecotypes, growing at a ratio of two rice to one red rice plant, reduced the leaf expansion of KBNT rice by 26 to 29% relative to rice growing alone.

Red Rice and Rice Tiller Density

Red rice tiller production was not affected by red rice ecotype or the ecotype by red rice population density interaction from 49 to 70 DAE in 1997 (Table 1). In 1998, red rice tiller density was affected by the ecotype by time of sampling interaction. Stgstraw and KatyRR had comparable tiller densities at 49 DAE, but at 70 DAE the densities of Stgstraw were 60% greater than those of KatyRR. LA3 produced 34 and 63% more tillers than KatyRR at 49 and 70 DAE, respectively. In contrast LA3 produced only 24 and 8% more tillers than Stgstraw at 49 and 70 DAE, respectively. Estorninos et al. (2002) showed that the taller LA3 produced more tillers than shorter KatyRR whether planted alone or in mixtures with rice. Generally, red rice produced 42% more tillers than did cultivated rice (Noldin et al. 1999). In a related study, monoculture of Stgstraw produced an average of 12 and 24 tillers $plant^{-1}$ at 49 and 70 DAE, respectively (Estorninos et al. 2005). When planted together, red rice produced 8 and 11 tillers $plant^{-1}$ at 49 and 70 DAE, whereas rice had only 2 tillers $plant^{-1}$ at both sampling dates (detailed data not presented). Red rice tiller densities were similar among population densities across time of sampling for both 1997 and 1998.

The tiller production of rice was not affected by the ecotype by time of sampling interaction in both years (data not presented). Rice tiller production was similar among the three red rice ecotypes in 1997, but in 1998, it was reduced by ~11% more in the presence of Stgstraw compared to the other red rice ecotypes. LA3 grew slowly until 49 DAE such that it and KatyRR reduced rice densities to similar levels. During this early stage, rice apparently develops an ability to reduce the growth of red rice through competition (Gibson et al. 2003; Ni et al. 2000).

Red rice reduced rice tiller production by 11 to 18% in 1997 and 12 to 15% in 1998, and the reduction generally increased with red rice population density. The reduction of rice tiller density probably resulted in part from the profuse tillering of red rice plants and their capacity to occupy more space than the rice cultivar. High tillering capacity has been recognized as a key to the competitive advantage for red rice against cultivated rice (Eleftherohorinos et al. 2002; Estorninos et al. 2002). Tiller densities for each of the three red rice ecotypes generally increased by at least 50% from 49 to 70 DAE in both years (Table 1), whereas rice tiller densities in corresponding plots were reduced by as much as 27% during the same time period (data not shown). Thus, the transitional period between 49 and 70 DAE was clearly one in which the red rice ecotypes gained a competitive advan-

TABLE 1. Red rice tiller densities at various sample times in 1997 and 1998.[a]

Red rice ecotypes	Red rice tiller density: 1997, Sampling time, DAE[b] 49	1997: 70	1998: 49	1998: 70
	no. m^{-2}			
Stgstraw	174	281	271	513
KatyRR	165	248	235	205
LA3	191	324	357	559
LSD (0.05)[c]	NS		105	
LSD (0.05)[d]	NS		116	

[a] Tiller densities represent means from the three red rice population densities established each year.
[b] Abbreviations: DAE, days after emergence; Stgstraw, Stuttgart strawhill; KatyRR, katy red rice; LA3, Louisiana 3; LSD, least significant difference.
[c] To compare time of sampling means at the same red rice ecotype within each year.
[d] To compare red rice ecotype means within the same or different time of sampling means within each year.

Table 2. Aboveground biomass of three red rice ecotypes at three times of sampling.[a]

Red rice ecotypes	Aboveground biomass					
	1997			1998		
	Sampling time, DAE[b]					
	49	70	91	49	70	91
	g m^{-2}					
Stgstraw	194	397	747	193	962	1,330
KatyRR	117	265	391	146	347	546
LA3	146	334	799	133	733	1,270
LSD (0.05)[c]		90			178	
LSD (0.05)[d]		156			178	

[a] Biomass values represent means from the three red rice population densities established each year.
[b] Abbreviations: DAE, days after emergence; Stgstraw, Stuttgart strawhill; KatyRR, katy red rice; LA3, Louisiana 3; LSD, least significant difference.
[c] To compare time of sampling means for the same red rice ecotype within each year.
[d] To compare red rice ecotype means within the same or different time of sampling within each year.

Table 3. Red rice aboveground biomass as influenced by red rice population densities and time of sampling interactions in 1997 and 1998.[a]

Red rice population density at 21 DAE[c]	Aboveground biomass					
	1997			1998		
	Sampling time, DAE[b]					
	49	70	91	49	70	91
plants m^{-2}	g m^{-2}					
16 [25]	104	224	480	102	429	685
24 [32]	164	347	644	169	629	901
31 [51]	189	427	813	201	984	1,560
LSD (0.05)[d]		90			178	
LSD (0.05)[e]		165			199	

[a] Averaged over three red rice ecotypes.
[b] Abbreviations: DAE, days after emergence; LSD, least significant difference.
[c] Densities shown without and with brackets are from 1997 and 1998, respectively.
[d] To compare time of sampling means for the same red rice density within each year.
[e] To compare red rice density means for the same or different time of sampling within each year.

tage against rice with respect to tiller density. Averaged over ecotypes, rice tiller density present at 70 DAE was 22% less in 1997 and 10% less in 1998, compared to the density at 49 DAE (detailed data not shown). This phenomenon apparently was due in part because red rice is capable of producing more tillers than rice throughout the growing season (Estorninos et al. 2002), and because KBNT is a low-tillering cultivar, and thus is a poor competitor against weeds (Estorninos et al. 2002; Gealy et al. 2003) that is not able to sustain suppression of rapidly growing red rice.

Red Rice and Rice Aboveground Biomass

The three red rice ecotypes had similar biomass 49 and 70 DAE in 1997 (Table 2). At 91 DAE, Stgstraw and LA3 produced about 50% more biomass than KatyRR. In 1998, Stgstraw had 64 and 24% higher biomass at 70 DAE than KatyRR and LA3, respectively, whereas LA3 had 53% higher biomass than KatyRR. LA3 compensated for its early slow growth by producing more tillers and increasing leaf expansion such that at 91 DAE its biomass was comparable with that of Stgstraw. LA3 and Stgstraw produced nearly 60% greater biomass than KatyRR, probably because those two ecotypes were taller and had greater leaf area (Noldin et al. 1999).

Averaged over ecotypes, red rice biomass was similar at all population densities at 49 DAE in both years (Table 3). In 1997, biomass of red rice at the density of 16 plants m^{-2} was comparable with 24 plants m^{-2} at 70 and 91 DAE. Biomass of plants grown at 16 plants m^{-2} was lower by 48 and 41% at 70 and 91 DAE, respectively, compared with 31 plants m^{-2}. Although red rice biomass in 1998 did not differ at 49 DAE, it was greater at 70 and 91 DAE with increasing density.

KatyRR, having almost the same height as KBNT at any population density, and Stgstraw at 16 plants m^{-2} did not affect rice biomass (data not shown). KBNT biomass was reduced about 15% by both the 24 and 31 plants m^{-2} of Stgstraw plants. LA3 reduced rice biomass 13% at the 16 plants m^{-2} and by 20% at 31 plants m^{-2} density. The rapid growth of LA3 from 70 DAE onward resulted in 13% rice biomass reduction even at the lowest red rice density in 1997. The rice biomass reduction was relatively low when rice was grown with 24 LA3 plants m^{-2} when compared with no red rice, but biomass was reduced by 20% with 31 LA3 plants m^{-2}, demonstrating that taller red rice can reduce rice growth even at low populations.

The three ecotypes did not affect KBNT biomass until 70 DAE in both years (Figure 2). At 91 DAE, LA3 red rice reduced KBNT biomass 15% more than KatyRR or Stgstraw red rice in 1997, whereas LA3 and Stgstraw red rice had similar effects on rice compared with KatyRR in 1998. Although LA3 produced similar or lower levels of biomass than Stgstraw, it reduced aboveground biomass of rice more than did Stgstraw relative to the effect of KatyRR. This could be due to a cumulative competitive pressure against rice that results from the taller stature and tendency toward greater tillering in LA3 compared with Stgstraw. KatyRR was short and not very competitive against rice compared with the other two ecotypes.

In 1997, the biomass of rice grown with red rice was comparable with that grown without red rice at 49 and 70 DAE (data not shown). When red rice population was nearly doubled in 1998, all planting densities reduced rice biomass at 70 and 91 DAE, and higher densities generally caused greater reductions (Figure 3). The reduction of biomass of rice grown with 25, 32, and 51 red rice m^{-2} ranged from 28 to 43% at 70 DAE and 28 to 51% at 91 DAE. Reduction difference caused by red rice ecotypes and the influence of the population densities on rice growth were observed at 91 DAE in 1997 and as early as 70 DAE in 1998.

Red Rice and Rice Yield

Yield of red rice was affected by ecotype by population density interactions in both years (data not shown). In 1997, LA3 consistently yielded more than Stgstraw (67 to 50%) and KatyRR (84 to 88%) at population densities of 16 to

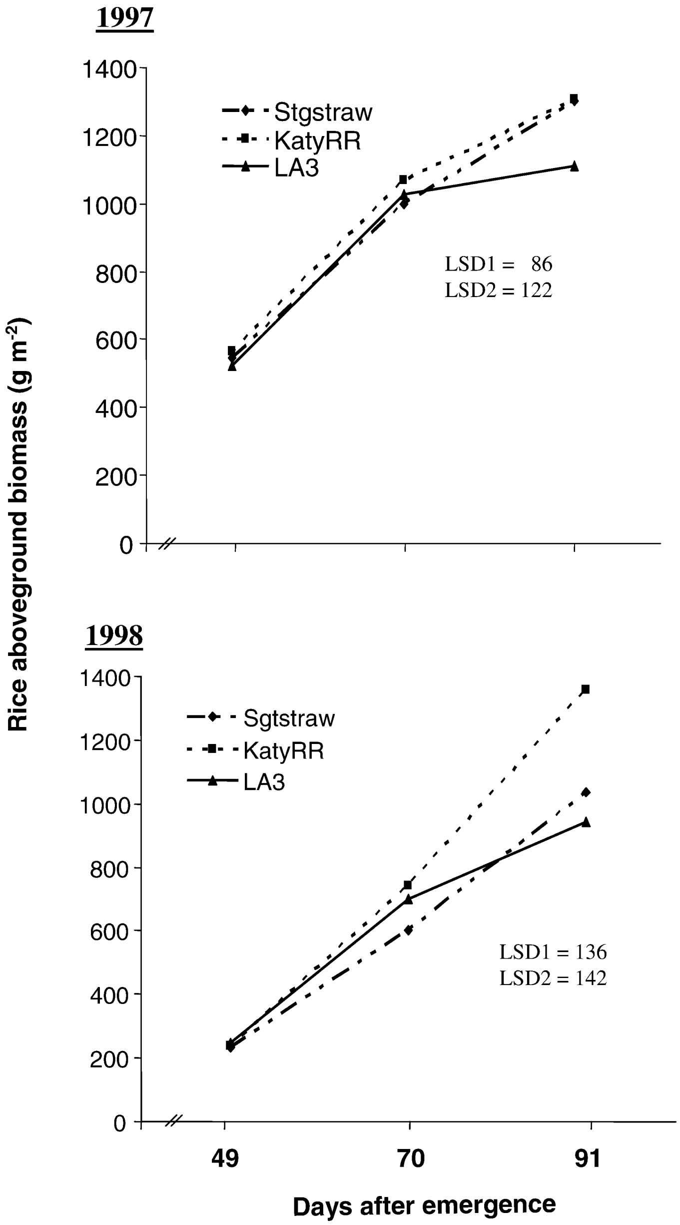

FIGURE 2. Rice aboveground biomass in 1997 and 1998 as influenced by three red rice ecotypes at three stages of growth. Data were averaged over four population densities. Least significant difference (LSD)1 (0.05) compares time of sampling means in the same red rice ecotype and LSD2 (0.05) compares ecotype means for the same or different time of sampling.

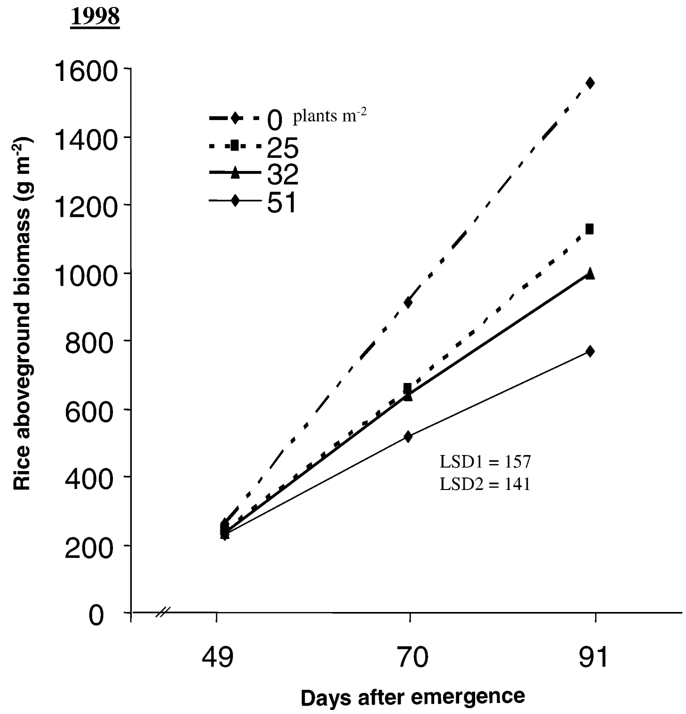

FIGURE 3. Rice aboveground biomass in 1998 as influenced by red rice population densities at three stages of growth. Data were averaged over three red rice ecotypes. Least significant difference (LSD)1 (0.05) compares times of sampling means at the same population density and LSD2 (0.05) compares population density means for the same or different time of sampling.

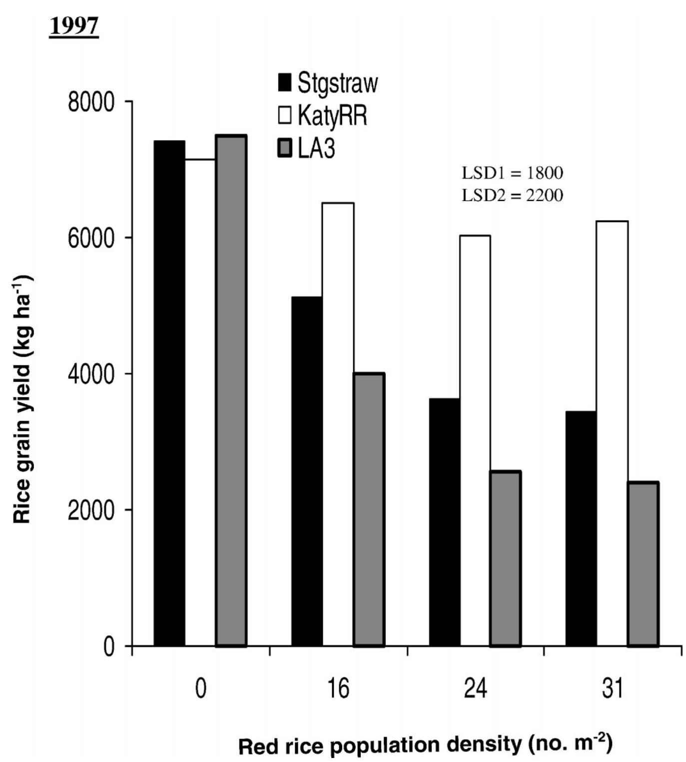

FIGURE 4. Rice grain yield in 1997 as influenced by three red rice ecotypes at four population densities. Least significant difference (LSD)1 (0.05) compares population density means at the same red rice ecotype and LSD2 (0.05) compares ecotype means for the same or different population density.

31 plants m^{-2}. LA3 is such a prolific seed producer that at its highest population density while in competition with KBNT, it produced yields (~7,400 kg ha^{-1}) similar to those of KBNT in weed-free plots. LA3 also reduced the yield of rice more than the other two ecotypes (Figure 4). When grown at 16 plants m^{-2}, LA3 reduced rice yields 22 and 38% more than Stgstraw and KatyRR, respectively. LA3 reduced rice yields 40 and 74% more, respectively, than did Stgstraw and KatyRR at the planting rate of 24 red rice plants m^{-2}, and reduced rice yields 45 and 61% more, respectively, at 31 red rice plants m^{-2}. About 75% of the LA3 plants at the highest planting density (31 plants m^{-2}) lodged at the hard dough stage in 1997 and resulted in a rice yield reduction similar to that caused by 24 red rice plants m^{-2}. Red rice can be highly susceptible to lodging (Noldin et al.

1999), which may be triggered at higher population densities (i.e., the higher densities used in this study). Stgstraw reduced the yield of rice from 29 to 33% when densities increased from 16 to 31 red rice m^{-2}. Fischer and Ramirez (1993) reported that rice yield was reduced by 40 and 60% when rice was grown with 5 and 20 red rice plants m^{-2}.

In 1998 when compared with KatyRR, LA3 reduced rice yield 68% (6,200 vs. 2,000 kg ha^{-1}) [LSD (0.05) = 1,300] and Stgstraw 48% (6,200 vs. 3,200 kg ha^{-1}). Thus, the interspecific interference activity of KatyRR against rice was less than for the other two ecotypes. Rice always yielded less when planted with red rice than when planted alone (7,700 vs. 2,500 kg ha^{-1}) ([LSD (0.05) = 1,600]). Generally, the yield of rice decreased as the density of red rice increased. Nearly all of the Stgstraw and LA3 plants lodged during the dough stage, which also pulled down the rice and could have contributed to the overall low rice yields and lack of significance among population densities.

Our results demonstrate that LA3, which was taller than the other two red rice ecotypes, had the greatest effect on productivity of KBNT rice. LA3 generally reduced the LAI of KBNT and consequently its yield, probably because of high tiller production. Stgstraw red rice reduced KBNT growth less than did LA3. KBNT competed well against the shorter KatyRR, even at increased red rice densities. These results agree with the previous reports that competitiveness of plants is associated with tiller production, leaf length, LAI, dry weight, and plant height (Estorninos et al. 2002), and red rice ecotypes (Fischer and Ramirez 1993; Noldin 1999). Grain yield of rice was reduced 29% with the interference of 16 red rice plants m^{-2} and 79% with 51 red rice plants m^{-2}.

Overall, these results demonstrate that even low populations of common ecotypes such as LA3 and Stgstraw can reduce rice growth and yield, whereas short-statured red rice types, like KatyRR, are likely to affect rice growth much less. Kwon et al. (1991) showed that one red rice m^{-2} could reduce rice grain yields, and Smith (1988) set a threshold infestation level of one to three red rice plants m^{-2} for control practices to avoid rice yield and quality losses. The observed slow early growth of the tall and very competitive LA3 may be exploited by planting an earlier-maturing and high-tillering rice cultivar. KBNT is a mid-season, medium-tall, and low-tillering rice cultivar. Substantial reduction of Stgstraw red rice growth by a high-tillering *indica* rice cultivar (PI 312777) in a related study (Estorninos et al. 2005) appears to support this contention. Several other high-yielding and early-maturing *indica* lines are being evaluated by geneticists at the Dale Bumpers National Rice Research Center, Stuttgart, AR (Rutger et al. 2005). Such weed-suppressive abilities in rice cultivars could help alleviate red rice management problems arising from the lack of effective selective herbicides in dry-seeded rice and also in weed management programs designed to reduce herbicide use.

Sources of Materials

[1] Licor LI 3000A Portable Area Meter, LI3050A/4, Li-Cor Inc., 4308 Progressive Ave., Lincoln, NE 68504.

[2] PQ21B Delnet bag. Applied Extrusion Technologies Inc., P.O. Box 582, Middletown, DE 19709.

[3] Dickey-john Multi-grain Moisture Tester. Seedburo Equipment Co., 1022 W. Jackson Blvd., Chicago, IL 60607.

[4] SAS Institute, Inc. 1999. SAS OnlineDoc, Version 8, SAS Institute Inc., SAS Campus Drive, Cary, NC 27513.

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